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Renewable and Sustainable Energy Reviews 13 (2009) 291–295

RENEWABLE & SUSTAINABLE ENERGY REVIEWS

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Potential contribution of ethanol fuel to the transport sector of Pakistan

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Received 29 June 2007; accepted 20 July 2007

Abstract

Pakistan is an energy-deficient country. The indigenous reserves of oil and gas are limited and the country is heavily dependent on the import of oil. The oil import bill is a serious strain on the country's economy and has been deteriorating the balance of payments situation. The country has become increasingly more dependent on fossil fuels and its energy security hangs on the fragile supply of imported oil that is subject to disruptions and price volatility. The transport sector has a 28% share in the total commercial energy consumption in Pakistan. About 1.15 million tonnes of gasoline was consumed by this sector during 2005–2006. The gasoline consumption in the transport sector is also a major source of environmental degradation especially in urban areas. Consequently, Pakistan needs to develop indigenous, environment-friendly energy resources, such as ethanol, to meet its transport sector's energy needs. Pakistan produces about 54 million tonnes of sugarcane every year. The estimated production potential of ethanol from molasses is about 500 million liters per annum. Ethanol can be used in the transport sector after blending with gasoline, in order to minimize the gasoline consumption and associated economical and environmental impacts. This paper presents the assessment of the potential contribution of ethanol in the transport sector of Pakistan. It is concluded that 5–10% of the annual gasoline consumption in transport sector could be met from ethanol by the year 2030 under different scenarios. About US$200–400 million per annum could be saved along with other environmental and health benefits by using gasol in the transport sector.

Keywords: Ethanol; Gasol; Transport sector; Renewable energy; Pakistan

Contents

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1364-0321/$ - see front matter
doi:10.1016/j.rser.2007.07.007

1. Introduction

Pakistan is an energy-deficient country. The indigenous reserves of oil and gas are limited and the country is heavily dependent on the import of oil. With the present rate of production, the indigenous recoverable reserves of oil and gas will get exhausted after 13 and 21 years, respectively. The country is meeting about 86% of oil demand from imports by spending around US$6.65 billion per annum. It is expected that the oil import bill will increase in the future due to rising oil prices and demand. The oil import bill is a serious strain on the country's economy and has been deteriorating the balance of payment situation. The country has become increasingly more dependent on fossil fuels and its energy security hangs on the fragile supply of imported oil that is subject to disruptions and price volatility [1–3].

Transport system is an important element of the enabling environment for economic growth. Regions with adequate means of transportation have grown economically and those lacking in this vital field have historically lagged behind. In Pakistan, the transport system consists of roads, railways, air and shipping transport services. Among these, road transportation is not only the most popular and widely used, it is also the only mode which is available to most of the population. Road transport is a backbone of Pakistan's transport system, accounting for 90% of national passenger traffic and 96% of freight movement. The road traffic—both passenger and freight—has grown much faster than the country's economy. The number of vehicles have jumped from 0.8 million to about 4.0 million within 20 years, showing an overall increase of more than 400%. The average compound growth of vehicles is about 11% per annum. Since 1980, the maximum growth has been seen in vehicles such as delivery vans, which is approximately 1751%, followed by motorcycles 541% and rickshaws 159% [1,2].

The consumption of fossil fuels in the transport sector is a major source of environmental pollution in the country. Air pollution from the use of gasoline and diesel oil in automobiles is increasing with the increasing number of vehicles. Most motorcycles and rickshaws, due to their two-stroke engines, are the most inefficient in burning gasoline fuel and contribute most to emissions. This is adversely affecting the quality of air, especially in the metropolitan areas. Air pollution levels in Pakistan's most populated cities are among the highest in the world and climbing, causing serious health issues. The levels of ambient particulates—smoke particles and dust, which cause respiratory disease—are generally twice the world average and more than five times as high as in industrial countries and Latin America. Various surveys show that air pollution levels in cities have either crossed safe limits or have reached the threshold values [1,2].

The pollutants emitted from transport sector in the urban areas are truly dangerous to human health. Nearly, 2500 people die every year due to air pollution related to vehicular emissions inflicting economic losses of about 250 to US$350 million. This loss to the national exchequer is colossal when compared to the costs of pollution abatement. Failures in the incorporation of these factors in economic policies contribute to significant losses to GDP and create many health/environmental problems. This heavy expenditure on environmental degradation is also affecting adversely every sector of the national economy [1,4].

Consequently, Pakistan needs to develop indigenous, renewable and environment friendly fuels to meet its transport sector's growing energy needs. Ethanol is one such fuel. There is a vast potential for ethanol production from molasses of sugarcane in the country. Industrial ethanol is produced through fermentation of molasses and subsequent distillation. It is then converted into fuel ethanol through molecular sieve technology. Fuel ethanol can be used in transport sector as pure ethanol or after blending with gasoline (gasol) [1,4]. Ethanol has a calorific value of 29.6 MJ/kg. The comparison of energy content of different fuels is shown in Table 1 [5].

This paper presents an overview of the fuel consumption patterns and the potential contribution of fuel ethanol in meeting the energy needs of the transport sector of Pakistan.

2. Energy consumption patterns in the transport sector of Pakistan

Transport sector is one of the major consumers of commercial energy in Pakistan. It accounted for about 28% of the total final commercial energy consumed (33.95 MTOE) and 55.8% of the total petroleum products consumed (15 MTOE) in the country. About 90.4% of fuel used in this sector is oil—mainly gasoline and diesel. Compressed natural gas (CNG) and electricity meets the remaining 9.6% requirements as shown in Fig. 1 [3].

The consumption of transport fuel has increased at an average annual growth rate of 6.7% during the last three decades. The share of transport fuel in total final commercial energy consumption has increased from 22.7% to 28% in the period 1972–2006. This increase in share of transport fuel demand was due to social and economic progress, rapid urbanization and aggressive financing policies of GOP and financing institutions [6].

It is expected that the demand of transport fuel in Pakistan would increase in future due to strong economic growth, dramatic shift in the population to urban centers and the rapidly increasing demand for transportation. Under the Business As Usual (BAU) scenario, the gasoline demand in the transport sector of the country is projected to increase from 1.15 to 5.75 million tonnes (by a factor of 5) during the period 2005–2030 [6].

3. Potential of fuel ethanol production in Pakistan

Pakistan is an agrarian country. Sugarcane is one of the major crops of the country. Pakistan stands fifth among the countries having a large tract of area under sugarcane

Table 1
Comparison of energy content of different fuels [5]

Fuel	Energy content (MJ/kg)
Gasoline	46.4
Diesel	45.6
Ethanol	29.6
Methanol	19.7

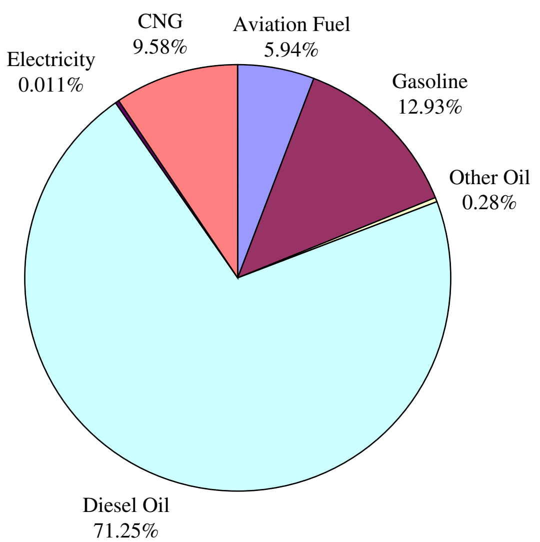


Fig. 1. Energy consumption in the transport sector of Pakistan during 2005–2006.

crop. About 53.5 million tonnes of sugarcane is produced every year in the country. The production of the molasses from sugarcane stands at about 4% of the sugarcane crushed. On an average ethanol recovery from 1 tonne of molasses is estimated at 240–270 l depending on the quality of molasses. The potential of ethanol production from molasses has been estimated at about 500 million liters or 0.42 million tonnes per annum, which is about 36% of the present gasoline consumption in the transport sector in Pakistan [6–8].

During the last 25 years, the production of sugarcane and beet increased at an average growth rate of 2.7% per annum. Assuming the same growth rate of sugarcane and beet production for the future, the potential of ethanol production has been projected to be about 1017.4 million liters for the year 2030 [6].

Sugar mills have invested over 1 billion dollars in the installation of 17 ethanol producing units after the directives of President Pervez Musharraf in January 2006 to blend 5% ethyl alcohol in motor gasoline for use in automobiles, keeping in view the rising oil prices [9].

4. Benefits of ethanol use in the transport sector

The use of ethanol as transport fuel has many advantages. The blending of ethanol with gasoline will reduce the gasoline import and the corresponding import bill. The use of indigenous fuel guarantees a certain degree of security of energy supply. The addition of ethanol to petrol enhances the octane value and thereby improves the efficiency of the engine. Ethanol has a lower vapor pressure than gasoline which results in lower evaporative emissions. Ethanol's flammability in air is also much lower than that of gasoline which reduces the number and severity of vehicle fires. Burned in internal combustion engines, ethanol fuel releases less CO and SO_2 emissions than gasoline and diesel fuels. Ethanol use as a transport fuel realizes a greenhouse benefit [8–11].

Ethanol production from molasses will boost employment for neighboring populations. Implementation of ethanol production from molasses will bring additional revenue to the sugarcane industry which is facing threats of price and quota reduction in the preferential markets in the context of trade liberalization. Besides, ethanol production from molasses is a climate friendly technology that can attract GEF funding as well as financing schemes such as Activities Implemented Jointly and the Prototype Carbon Fund [8–11].

5. Potential contribution of fuel ethanol in meeting future energy demand in the transport sector of Pakistan

As described earlier, fuel ethanol can be used in the transport sector as pure fuel or after blending with gasoline. A blend of ethanol and gasoline (ratio of 10:90 or 20:80) is acceptable for use as motor fuel. No change in car engine is required for a 10% blend. Substitution of petroleum by ethanol as a motor fuel has already gained universal recognition. Several countries of the world have successfully developed their fuel ethanol program. US, India, Brazil and European Union have used the ethanol fuel in aircrafts, automobiles, trucks and tractors. Currently, almost all of the vehicles manufactured in Brazil have been fitted with flex fuel engines. These vehicles are working well and have no obvious environmental consequences [1,11].

In a recent development, Pakistan State Oil has launched E-10 gasoline pilot project at designated retail outlets in Karachi, Lahore and Islamabad. It is based on a detailed feasibility study conducted by the Hydrocarbon Development Institute of Pakistan (HDIP). The new fuel—10% ethanol blended with motor gasoline—is being introduced experimentally as part of government's strategy to promote alternative energy resources. The pilot project is being conducted for 6 months, with 25 pre-identified vehicles using ethanol-blended gasoline in each city. The monitoring of these vehicles will be carried out by HDIP. Based on the results of the project, the blended fuel would be made available throughout the country [12].

5.1. Methodology and results

A suite of four future scenarios depicting possible gasoline blending ratios and targets, and potential contribution of ethanol fuel in meeting Pakistan's energy

demand of transport sector over a 24-year time frame were developed for this study. The scenarios were low blending (LB), medium blending (MB), high blending (HB), and very high blending (VHB) of ethanol with gasoline. The blending shares of ethanol in gasol for different scenarios are presented in Table 2. It is assumed that the gasol program starts from 2008 and would be fully implemented by the year 2030.

The potential contribution of ethanol fuel in meeting the transport sector's energy demand (under BAU scenario) is predicted for all the considered scenarios up to 2030 and is shown in Fig. 2. Pakistan's expected consumption of gasoline in the year 2030 would be around 5.75 million tonnes. If the gasol program is implemented fully, the consumption of ethanol fuel in 2030 would be in the range of 0.288–1.15 million tonnes under different scenarios considered in this study. About 33.6%, 67.3% and 100% of the total estimated ethanol fuel production in the year 2030 would be utilized under LB, MB and HB scenarios, respectively. The estimated production potential of ethanol could not meet its projected demand in 2030 under VHB scenario. More indigenous production of ethanol from molasses and other sources would be required to meet its demand in 2030 under VHB scenario.

Table 2
Different ethanol blending scenarios

Scenario	Ratio of ethanol in gasol (%)
Low-blending scenario	5
Medium-blending scenario	10
High-blending scenario	15
Very high-blending scenario	20

Pakistan exports substantial quantity of alcohol annually. Other domestic consumption of alcohol includes usage in varnishes, paints, cosmetics, medicines, explosives, acetic acid, ethyl acetate, butyl acetate, acetone, acetic anhydride, acetate yarn, paper, leather, etc. [11]. Therefore, all the alcohol produced from molasses could not be used for fuel ethanol production. The results indicate that the projections for ethanol fuel demand under LB and MB scenarios are reasonable and could be met easily through indigenously produced ethanol fuel. By the year 2030, about US$200–400 million could be saved along with other environmental and health benefits by using gasol with 5–10% ethanol as transport fuel in the country.

6. Conclusion

The transport sector is one of the major consumers of commercial energy in Pakistan. Oil is the main fuel used in this sector. Oil is an imported commodity and is also not environment-friendly. There is substantial potential of ethanol fuel production from molasses in the country. Ethanol, an indigenous, renewable and environment-friendly fuel, can be used as pure fuel or after blending with gasoline in the transport sector.

The consumption of ethanol fuel is projected to be 0.288–1.15 million tonnes by the year 2030 under different scenarios. About US $200–400 million could be saved along with other environmental and health benefits by using gasol with 5–10% ethanol as transport fuel in the country.

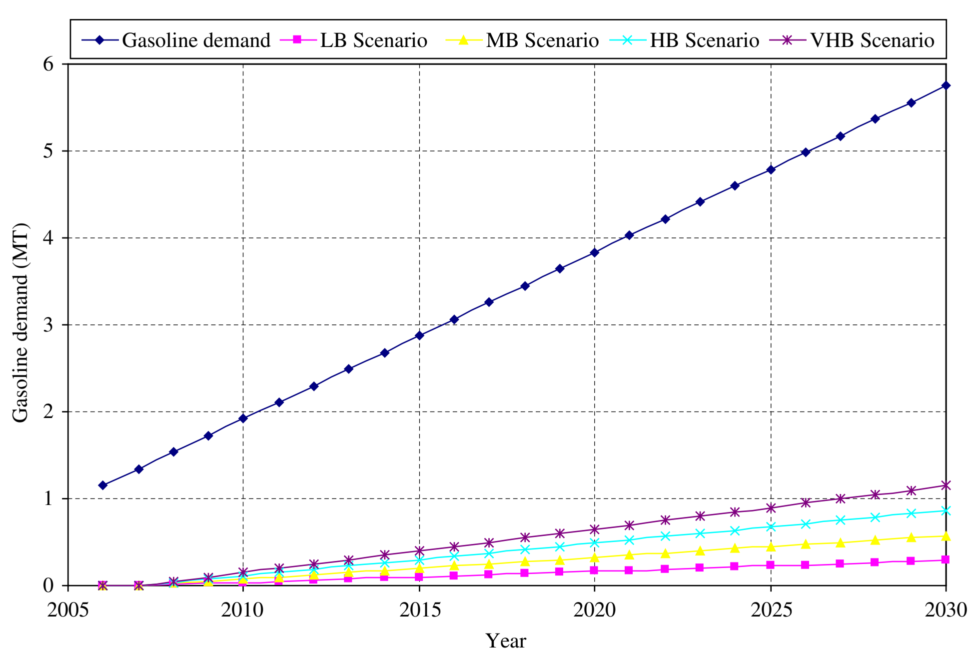


Fig. 2. Projections of ethanol consumption in the transport sector of Pakistan.

Acknowledgments

The authors acknowledge Department of Mechanical Engineering, Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan, for providing the laboratory facilities to carry out this research work. Research leading to this article has been financially supported by the Higher Education Commission (http://www.hec.gov.pk) of the Government of Pakistan.

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